General Energy

Introduction

Why Do We Look At Energy Issues?

Energy conservation at the manufacturing facility translates directly to resource conservation and cost reduction for the manufacturer. One of manufacturing's major goals should be increased efficiency in the use of resources. This not only conserves limited resources such as oil and coal needed to generate energy, but also impacts the company's bottom line. Energy conservation research and development has made great gains in the years since the oil embargo, and has increased the application of use reduction methodologies for small and midsized manufacturers. The MAP Toolkit contains several of these use reduction methodologies to help manufacturers in their efforts to conserve energy for their facility.

Most facilities can make improvements to increase energy efficiency. The most common opportunities are included in this module:

- Boilers
- Chillers and Cooling Towers
- Compressed Air Systems
- HVAC Systems
- Insulation, Ovens and Furnaces
- Lighting
- Motors and Drives
- Power Factor

Source

Modern Industrial Assessments: A Training Manual, Version 1.0b, produced by Dr. Michael R. Muller, Director, Michael Simek, and Jennifer Mak, The Office of Industrial Productivity & Energy Assessment, Rutgers, The State University of New Jersey, December, 1995.

General Energy
Boilers

In many industrial applications, boilers are used for process heating as well as heating the plant during the winter months.

A. Air and Fuel Ratio

Many factors including environmental considerations, cleanliness, quality of fuel, etc. contribute to the efficient combustion of fuels in boilers. It is therefore necessary to carefully monitor the performance of boilers and tune the air/fuel ratio at least twice per year.

B. Recover Heat from Boiler Stacks

Installing heat exchangers in the stacks will allow much of the energy that is exhausted away from the boiler to be recovered. The energy can be used to heat air before it is drawn into the combustion chambers of the boiler. This will allow the boiler to burn at higher efficiency, thus reducing fuel consumption.

C. Steam Distribution

Significant savings can be realized, by locating and repairing leaks in live steam lines, and in condensate return lines. Leaks in the steam lines allow steam to be wasted, resulting in higher steam production requirements from the boiler to meet the system needs.

D. Solution

Possible recommendations related to Boilers are:
- Adjust fuel and air ratios
- Repair steam leaks
- Recover heat from boiler stacks
- Return steam condensate to boiler
- Insulate steam lines

E. Economics

Opportunity Areas and Potential Savings Range:
- Adjust air-fuel ratio, 10% - 15%
- Install Stack Heat Exchanger, 10% - 25%
- Return Steam Condensate to Boiler, 5% - 8%

F. Sample Scope of Work and Deliverables

- Project manage a design of heat recovery from boiler stacks.
- Publish request for quotation for vendors and evaluate subsequent design options.
- The customer will receive a report with design options and specifications.
- The customer will receive an evaluation of project bids and recommendations for vendor choice.

G. References

- http://www.kewaneeboiler.com/
- Boiler Efficiency Improvement; Boiler Efficiency Institute, Auburn, AL, 1981

General Energy

Boilers

Checklist

Is/are the boiler(s) used for production processes?

☐ Yes ☐ No
(If No, STOP)

1. How often is the boiler tuned?

   ☐ Yearly ☐ Semi-annually ☐ Quarterly
   (If Yearly, go to A)

2. Are stack heat exchangers used?

   ☐ Yes ☐ No
   (If No, go to B)

3. Is the stack temperature over 400 °F?

   ☐ Yes ☐ No
   (If Yes, go to B)

4. Are steam leaks visible?

   ☐ Yes ☐ No
   (If Yes, go to C)

Additional Questions

- What is/are the boiler rating(s)?
- What is the operation time (hr/yr)?
- What is the stack gas temperature?
- What is the number of steam leaks and size of each leak?

Note: Remember to also look at insulation associated with the boilers.

MEDS Links (http://meds.mmtc.org)

- Condensate Return
- Economizer
- Heat Pipes
- Install Small Boiler
- Recover Steam Blowdown
- Steam Traps
- Turbulators
- Water Preheater

General Energy
Chillers and Cooling Towers

Many plants have chillers that provide cooling for various plant processes. Chillers consist of a compressor, an evaporator, an expansion valve, and a condenser, and are classified as reciprocating chillers, screw chillers, or centrifugal chillers, depending on the type of compressor used. Reciprocating chillers are usually used in smaller systems (up to 25 tons [88 kW]), but can be used in systems as large as 800 tons (2800 kW). Screw chillers are available for the 80 tons to 800 tons range (280 kW to 2800 kW), but are normally used in the 200 tons to 800 tons range (700 kW to 2800 kW). Centrifugal chillers are available in the 200 tons to 800 tons range, and are also used for very large systems (greater than 800 tons [2800 kW]).

A. Variable Speed Motors for Cooling Tower Fans

The outdoor wet-bulb temperature affects cooling tower performance. During periods of lower outdoor wet-bulb temperature, the design amount of cooling can be obtained with lower airflow rates. As the air flow rate decreases, the fan speed and the motor power requirements also decrease. It may be beneficial to install a two-speed motor for the cooling tower fan to reduce the fan motor power consumption. It should also be noted that variable speed drives for fan motors achieve cooling tower energy savings in the same manner as two-speed motors.

B. Condenser Water Temperature

The power consumption of any chiller increases as the condensing water temperature rises. This is because, as the condenser temperature increases, the pressure rise across the compressor increases and, consequently, the work done by the compressor increases. Condensing water temperature setpoints are typically in the range between 65°F and 85°F, but can be as low as 60°F. In many cases the setpoint temperature is in the middle of the range, at about 75°F. Rule of thumb: there is a 0.5% improvement in chiller efficiency for each degree Fahrenheit decrease in the setpoint temperature for the condenser water.

C. Chilled Water Supply Temperature Adjustment

The efficiency of chillers increases as the chilled water temperature increases. There is approximately a 1% increase in efficiency for each degree Fahrenheit increase in the chilled water setpoint temperature.

D. Solution

Possible recommendations related to Chiller and Cooling Towers are:

- Adjust temperature
- Install variable speed motors for cooling tower fans

E. Economics

Cooling tower design and performance is controlled by wet bulb temperature. At design conditions (i.e. fully loaded, maximum CFM) the approach temperature for the tower should be about 7 degrees Fahrenheit. The approach temperature is defined as the temperature of the return cold water, minus the current wet bulb temperature. The temperature drop across the tower at the design conditions can be maintained at 10 degrees. During lower fan speed operation, the approach would increase (i.e. the colder wet bulb would allow lower air flow). For example, if the air flow rate is cut by 50% (due to speed reduction of 50%), the approach temperature would be approximately doubled, and the towers could maintain the same temperature drop, and therefore handle the same load.

Anticipated Savings

Savings occur because at low speed, the power required to deliver a unit of cooling air (i.e. per cfm), is much less than at high speed. The power draw by a fan is proportional to the cube of the fan speed.

Note that the power rating of the motor at half speed is slightly greater than the value that would be expected using the affinity laws directly. This is because the motor operates at a lower efficiency when running at lower speed. The correction for this efficiency difference is estimated at approximately 15% (i.e. power values are estimated as 15% greater than those calculated from affinity laws).

General Energy

Chillers and Cooling Towers

Chiller Efficiency Improvement

(Savings from reducing condenser temperature)

	Condenser Water Temperature Reduction, °F			
Machine Type	**1 °F**	**2 °F**	**3 °F**	**4 °F**
Absorption	0.5%	1.1%	1.6%	2.1%
Centrifugal	1.1%	2.2%	3.3%	4.4%

	Condenser Water Temperature Reduction, °F			
Machine Type	**5 °F**	**6 °F**	**8 °F**	**10 °F**
Absorption	2.6%	3.2%	4.2%	5.3%
Centrifugal	5.5%	6.6%	8.8%	11.0%

Efficiency of a Cooling Tower

(Cooling water inlet temperature - cooling water exit temperature) / (Cooling water inlet temperature - wet bulb temperature of Ambient air)

F. Sample Scope of Work and Deliverables

Future work related to Chiller and Cooling Towers is unlikely.

G. References

- http://www.pnl.gov/fta/6_appa.htm
- *Energy Conservation Techniques for Engineers*, Zackrison, H.B., 1984

Checklist

Does the facility operate chillers for a full shift (or more)?

☐ **Yes** ☐ **No**
(If No, STOP)

1. Does the cooling tower have a variable speed motor or a two-speed motor?

☐ **Yes** ☐ **No**
(If No, See A)

2. Is the condenser water temperature below 65 °F?

☐ **Yes** ☐ **No**
(If No, See B)

3. Is the required temperature of the chilled water within five degrees of the chiller-set point?

☐ **Yes** ☐ **No**
(If No, See C)

Note: Remember to also look at Insulation and Motors and Drives associated with the chillers and cooling towers.

MEDS Links (http://meds.mmtc.org)

- AC Chillers
- Natural Gas Chillers

General Energy
Compressed Air Systems

Compressed air is perhaps the most expensive form of energy used in an industrial setting. This is because 90% of the energy used is converted into heat while only 10% is actually converted to compressed air energy.

A. Outside Air

The work required to compress air under usual operating conditions in manufacturing plants is proportional to the absolute temperature of the intake air. Typically, intake air to the compressor is 20 to 30 degrees F warmer than actual outside air. By lowering the intake air temperature, savings can be obtained.

B. Synthetic Lubricants

Synthetic lubricants have demonstrated an ability to provide energy savings due to reduced friction and heat on bearings, gearboxes, and other related parts. They also increase the service life of these components.

C. Pressure Setting

Reducing the line pressure would save substantial energy since most equipment requires 80 - 100 psi. Increasing the pressure to increase the volume of compressed air is not economically advisable.

D. Air Leaks

Because of the high inefficiency of producing compressed air, a seemingly insignificant air leak actually translates into a measurable energy loss. In a typical manufacturing firm, about 10% of compressed air generated is lost through leaks.

E. Solution

Possible recommendations related to Air Compressors are:

- Use outside air at the intake
- Use synthetic lubricants in compressors
- Reduce the line pressure to the minimum required
- Identify and fix air leaks

F. Economics

To calculate operating costs for an existing system, use the MAP Web Report Writer to calculate the Fractional Reduction and Operating Cost. The web site can also be used to calculate the potential savings for each potential solution.

G. Sample Scope of Work and Deliverables

Future projects related to Air Compressors are not likely.

H. References

- http://air.ingersoll-rand.com/
- Marks' Standard Handbook for Mechanical Engineers,McGraw Hill, 1987

General Energy

Compressed Air Systems

Checklist

Is/are the compressor horsepower rating(s) at 25 HP or greater?

☐ Yes ☐ <u>No</u>
(If No, STOP)

1. Is outside air used at the air intake?

☐ Yes ☐ <u>No</u>
(If No, See A)

2. Are synthetic lubricants being used in the compressor?

☐ Yes ☐ <u>No</u>
(If No, See B)

3. Is the current pressure set at greater than 100 psi?

☐ <u>Yes</u> ☐ No
(If Yes, See C)

4. Do air hoses in the facility have noticeable air leaks?

☐ <u>Yes</u> ☐ No
(If Yes, See D)

Additional Questions

- What is/are the horsepower rating(s)?
- What is the operating pressure?
- What is the maximum pressure?
- What are the operating hours?

Note: Remember to also look at Motors and Drives associated with the air compressors.

MEDS Links (http://meds.mmtc.org)

- Air Knife Dryer/Cleaner
- Condensate Drain
- Natural Gas Air Compressor
- Rotary Vane Air Compressor

General Energy

HVAC Systems

Optimization of HVAC Systems can result in energy savings and increased comfort of building occupants.

A. HVAC Systems Basics

Operate systems only when needed. Reduce operating hours of HVAC system to match occupancy patterns. Eliminate over cooling and over heating. Use ranges of minimum and maximum acceptable temperatures rather than absolute temperatures.

B. Equipment Maintenance

Preventive Maintenance should include checking pressure drop across filters, cleaning, replacing filters, checking for tight damper seals, and inspecting fans.

C. Mechanical Cooling and Heating Minimization

- Make sure that system has an Economizer Cycle to utilize up to 100% outdoor air for cooling when air is cooler than inside air.
- Minimize makeup and exhaust air to avoid extra loads in heating and cooling.
- Minimize the amount of air delivered to a conditioned space. Required air changes vary. One change every 5 to 10 minutes is appropriate for most spaces.
- Recover energy via heat exchange from exhaust to makeup air.

D. Air Conditioning Opportunities

- Operate systems only when needed
- Eliminate overcooling and overheating
- Eliminate reheat
- Minimize mechanical cooling and heating
- Minimize makeup and exhaust air
- Minimize the amount of air delivered to a conditioned space
- Recover energy from heat
- Maintain equipment

E. Eliminate Reheat of Air for Humidity Control

Reheat of cooled air is no longer considered acceptable practice for normal comfort situations.

F. Other HVAC Opportunities

- Reduce temperature of spaces
- Reduce fan and pump horsepower by replacing motors
- Retrofit HVAC systems to some form of VAV (Variable Air Volume) systems
- Check Ventilation
- Shut down exhaust fans which are not in use
- Improve hood design to reduce exhaust volume

G. Economics

Savings associated with HVAC systems optimization are not predictable.

H. Sample Scope of Work and Deliverables

- Specify and project manage installation of economizer, heat recovery system, upgrade of control system or ventilation system components.
- Write and provide training on Preventive Maintenance plan with the goal of optimizing operation of existing HVAC system.
- Perform indoor air quality and comfort survey to diagnose any problems with ventilation systems.
- Report with design options for HVAC improvements
- Evaluate bids and make vendor recommendations
- Supervise installation of new equipment
- Perform or commission indoor air quality survey

I. References

- ASHRAE, *Handbook of Fundamentals*, 1972
- Industrial Ventilation, A Manual of Recommended Practice, 22nd Edition, ACGIH, Cincinnati, OH, 1995

General Energy

HVAC Systems

Checklist

Does the facility have any concerns about their HVAC System?

☐ Yes ☐ No
(If No, STOP)

1. Does the facility manually control the temperature?

☐ Yes ☐ No
(If Yes, See A)

2. If not manually controlled, is climate controlled to a single temperature (rather than a range of temperatures)?

☐ Yes ☐ No
(If Yes, See A)

3. Does the facility have a good preventive maintenance plan for HVAC equipment?

☐ Yes ☐ No
(If No, See B)

4. Is the HVAC system equipped with an economizer?

☐ Yes ☐ No
(If No, See C)

5. Is the heat generated from process equipment recovered for space heat?

☐ Yes ☐ No
(If No, See C)

6. Have there been any complaints by the employees about indoor air quality or comfort?

☐ Yes ☐ No
(If Yes, See A through F)

Note: Remember to also look at Insulation and Motors and Drives associated with the HVAC.

MEDS Links (http://meds.mmtc.org)

- AC Chillers
- Active Humidity Control
- Air Cleaners
- Destratification Fans
- GAX Heat Pumps
- Heat Pipes
- Low Intensity IR Heaters
- Natural Gas Chiller

General Energy

Insulation, Ovens and Furnaces

Upgrading or installing insulation on pipes, buildings, and hot and cold process equipment may be a source of significant energy and cost savings.
Ovens and furnaces utilize more energy than all other plant operations. There are several areas of interest with respect to ovens and furnaces:

- Insulation and refractory materials
- Fuel economy
- Heating cycle optimization
- Recovery of heat from exhaust gases

Installation of insulation on exposed surfaces of ovens and furnaces can be a significant source of savings.

A. Insulation Basics

Insulation is important to any operation where transfer of gases or liquids occur at temperatures different from ambient. The savings associated with proper use of insulation can be significant. Inhibited insulation means that the materials are treated or coated to minimize corrosion potential. Trapped water can damage insulation and cause equipment to corrode.

B. Insulation Types and Considerations

Fibrous Insulation: small diameter fibers divide up air space. Examples are glass, silica, rock wool, slag wool, or alumina silica. Fiberglass is an inexpensive option for applications of 50F – 850F but has low resistance to abuse and readily absorbs moisture.
Mineral Wool: has the lowest cost for higher temperature applications, 1200F to 1800F and is most appropriate for non-austenitic stainless steel and low abuse situations.
Cellular Insulation: small individual cells of air separated from each other. Examples are glass or foamed plastic.
Polyisocyanurate: insulation for applications of 140F – 300F and –100F to –300F. It has similar costs to Calcium Silicate, but better moisture resistance and is good for dual temperature applications. Foam glass is good for temperatures of 300F to 900F.
Granular Insulation: small nodules of material with voids or hollow spaces. Material may be loose, pourable or combined with binders to be rigid. Examples are calcium silicate, expanded vermiculite, perlite, cellulose, and diatomaceous earth. Calcium Silicate is relatively inexpensive and best for applications between 300F and 1200F.

C. Fuel Economy and Heating Cycle Optimization

Flue gas analysis showing the presence of hydrogen and carbon monoxide indicates a rich burning scenario. Presence of oxygen in the flue gas suggests a complete burn of the fuel but excess wasted air.
Burner and combustion controls may be upgraded by:

- Replacing open age-type burners with sealed-in burners
- Replacing inspirator or atmosphere burners with power burners
- Installing a fuel/air ratio control system

Furnace pressure controls can increase efficiency of ovens or furnaces. They also provide the shortest heating cycles and improved product quality.
Optimization of fuel burning equipment is vital to energy savings and efficiency. Inefficient burning of fuel is more likely If the facility does not have good documentation of operational changes, or if the operations and maintenance manual does not reflect the true operations of the facility.

D. Refractory Materials

Conventional refractory linings have poor insulation properties. Consider fiber liners between lining of equipment and refractory bricks.

E. Heat Recovery

Installing heat exchangers in the stacks will allow much of the energy that is exhausted away from ovens and furnaces to be recovered. The energy can be used to hear air before it is drawn into the combustion chambers. This will allow the units to burn at higher efficiency, thus reducing fuel consumption.

F. Solution

Look for opportunities for the facility to save energy by installing or upgrading insulation for hot or cold process equipment, piping, dock doors, etc. Energy savings opportunities associated with ovens and furnaces are complex and can involve the following aspects:

- Refractory linings and insulation
- Combustion controls
- Scheduling and operating procedures, preventive maintenance
- Heat Exchangers for recovery of exhaust heat
- Temperature controls
- Burner optimization

G. Economics

The annual energy savings (ES) resulting from insulating surfaces can be estimated using the equations given on the website using the information gathered in the Additional Information of the Checklist.

General Energy

Insulation, Ovens and Furnaces

H. Sample Scope of Work and Deliverables

- Perform a survey of insulation installed in building and production equipment to determine the effectiveness and appropriateness for each application.
- Project manage specification and installation of new insulation materials for the building or production equipment.
- Conduct and interpret Flue Gas Analysis for production ovens and furnaces.
- Project manage installation of oven and furnace improvements including refractory brick.
- Write and implement an operations and maintenance manual for ovens and furnaces.

I. References

- *Mark's Standard Handbook for Mechanical Engineers*, McGraw-Hill Book Company, 1987
- http://www.insulation.org National Insulation Association
- Thurman, A. and Mehta, D.P., *Handbook of Energy Engineering*, The Fairmont Press, 1992

Additional Questions

- What is the exposed side surface area of equipment?
- What is the surface temperature of equipment?
- What is the estimated average annual air temperature of surroundings?
- What is the annual operation time?
- What is the number of units (if multiple pieces of equipment, such as ovens)?
- For uninsulated steam piping, what are the approximate lengths and diameters?

MEDS Links (http://meds.mmtc.org)

- Heat pipes
- Insulation

Checklist

Does the facility use hot water, steam, or chilled water for production operations?

☐ Yes ☐ No

Does the facility use heated or chilled equipment (ovens, furnaces, plastic injection molding machines, etc.)?

☐ Yes ☐ No

Is the facility located in a cold climate?

☐ Yes ☐ No

(If No to all three questions, STOP)

1. Was existing insulation designed specifically for pipe sizes, fluid temperatures desired, and corrosion protection?

☐ Yes ☐ No
(If No, See A & B)

2. Is the heated or chilled equipment insulated?

☐ Yes ☐ No
(If No, See A & B)

3. Is there evidence that existing insulation is missing, in bad repair, or has been wet?

☐ Yes ☐ No
(If Yes, See A & B)

4. Are flames visible out of the oven or furnace doors?

☐ Yes ☐ No
(If Yes, See C)

5. Is there an opportunity for air/fuel controllers to maximize burner efficiency?

☐ Yes ☐ No
(If Yes, See C)

6. Has flue gas analysis been completed?

☐ Yes ☐ No
(If No, See C)

7. Does the facility have an operations and maintenance manual for ovens and furnaces?

☐ Yes ☐ No
(If No, See C)

8. Are ovens and furnaces lined with refractory materials?

☐ Yes ☐ No
(If No, See D)

9. Has the facility considered using heat exchangers to recover exhaust heat from ovens and furnaces?

☐ Yes ☐ No
(If No, See E)

General Energy
Lighting

Many lighting systems that represented good practice several years ago are inefficient in view of today's higher electrical costs. A facility's lighting is roughly 20-25% of its electric bill.

About 20% of energy costs at facilities can be attributed to indoor and outdoor lighting. Lighting energy can be wasted in several ways including transmission losses (lighting is blocked by dirt or other obstructions), over lighting and use of inefficient light sources.

A comprehensive Lighting Survey identifies the most energy efficient and best quality of lighting for a number of areas in a plant including shop, task and office lighting, exit signs, outdoor lighting, occupancy sensors for certain, low-use areas like conference rooms and warehouses.

A. HID Lighting

High-intensity discharge (HID) lamps have long service lives and high efficacy, making them the most energy efficient option for many lighting applications. HID lamps contain a sealed arc tube inside a glass bulb. The tubes contain small amounts of arc metals like mercury, sodium, and halide compounds. A continuous electric arc between two electrodes in an atmosphere of inert gas produces the light. Tubes may also have additional starting electrodes. HID lamps provide on order of magnitude, greater lumens per watt than standard incandescent lamps.

B. Occupancy Sensors

The most obvious and beneficial step to conserve energy is to turn off lights when they are not needed. Occupancy sensors detect when an employee has left and after a set period of time, turns off the lamp and turns it back on when an employee returns.

C. Photocell Sensors

Similar to occupancy sensors, photocell sensors automatically turn off electric lights when natural light is bright enough.

D. High-Efficiency Lamps and High-Frequency Ballasts

Significant savings can be realized by purchasing the newest technology in lighting. High-Efficiency lamps can reduce consumption by 15%, while electronic ballasts can save 20-25%.

E. LED Exit Signs

Savings of energy and labor may be achieved with the replacement of incandescent exit signs with LED exit signs. Energy savings are about $35 per year, and labor costs to change lamps and maintain equipment are practically eliminated. Lamp life for LEDs is up to 20 years without replacement. Inexpensive retrofit kits are available from several vendors.

F. Solution

Lighting retrofits are based upon analysis of lighting needs and existing equipment and calculation of payback. A lighting survey provides the facility with very specific recommendations and payback calculations with which lighting retrofit projects can be prioritized. Simple calculations and recommendations may be made using the economic feasibility features of the MEDS web pages related to Lighting.

G. Economics

- Savings of 10% to 30% of lighting costs may be achieved by the installation of lighting controls such as occupancy or photocell sensors.
- Savings of 10% – 25% or more can be achieved by replacement of existing ballasts with higher efficiency models.
- Savings of 5% – 15% or more can be achieved by replacement of existing with higher efficiency models.
- Savings of 95% can be achieved by replacement of incandescent exit signs with LED Exit signs.

H. Sample Scope of Work and Deliverables

Conduct Lighting Survey to identify specific lighting retrofit opportunities and recommend new lamps and fixtures.

I. References

- http://www.hubbell-ltg.com/
- Illuminating Engineering Society, *IES Lighting Handbook*, 1972

General Energy
Lighting

Checklist

Has the facility performed a lighting survey?

☐ Yes ☐ No
(If Yes, STOP)

1. Is the facility fitted primarily with HID lighting?
☐ Yes ☐ No
(If No, See A)

2. Are lights turned off in areas that are unoccupied?
☐ Yes ☐ No
(If No, See B and C)

3. Are lights turned off in areas where bright natural light from windows and skylights enters a space?
☐ Yes ☐ No
(If No, See C)

4. Is the company purchasing high-frequency electronic ballasts as a replacement for standard, burned out ballasts?
☐ Yes ☐ No
(If No, See D)

5. Are the fluorescent lamps high-efficiency?
☐ Yes ☐ No
(If No, See D)

6. Does the facility have incandescent exit signs?
☐ Yes ☐ No
(If Yes, See E)

MEDS Links (http://meds.mmtc.org)

- Compact Fluorescent Lamps
- High Efficiency Ballasts
- High Pressure Sodium Lamps
- Low Mercury Lamps
- LED Exit Signs
- Metal Halide Lamps
- Occupancy Sensors
- Photocell Sensors

General Energy

Motors and Drives

Typically, 70% of a facilities electric cost is in the form of motors. Facilities should replace motors with high efficiency motors as they wear out. Facilities should also replace standard v-belts with cogged v-belts for additional energy savings.

A. High-Efficiency Motors

Purchase of high-efficiency motors should be standard practice with any new purchases. Payback of the premium paid for high-efficiency motors is usually less than two years for motors operated for at least 4,000 hours and 75 percent load. An exception may exist when the motor is only lightly loaded or operating hours are low, as with intermittent loads. The greatest potential occurs in the 1 to 20 horsepower range. Above 20 horsepower efficiency gains become smaller, and existing motors over 200 hp are already relatively efficient. Motors that have been rewound are never as efficient as they were originally, therefore, it is always worth calculating the payback on the replacement of a motor before sending it out for rewinding.

B. High-Efficiency, Cogged V-Belts

Substitution of the notched V-belt (cog belt) for the conventional V-belt offers attractive energy savings. The V-belt is subjected to large compression stresses when conforming to the sheave diameter. The notched V-belt has less material in the compression section of the belt, there-by minimizing rubber deformation and compression stresses. The result is higher operating efficiency for the notched V-belt.

C. Economics

High efficiency motors can save up to 10% of energy costs. Replacing drive belts with cogged belts can save approximately 2.5% of energy costs.

Motor Efficiencies: The following table shows the current and proposed efficiencies of motors. The cost premium is the cost difference in purchasing a higher efficiency motor over a standard efficiency motor. This data is up to date as of February 1996.

D. Sample Scope of Work and Deliverables

Conduct a Motor Survey to identify specific motor improvements, which may be implemented at the facility.

E. References

- http://www.facilitiesnet.com (search for motors)
- *Energy Conservation Techniques for Engineers,* Zackrison, H.B., 1984

Motor Efficiencies Table			
HP Rating	Current EFFc	Proposed EFFp	Cost Premium
0.75	0.740	0.817	$35
1	0.768	0.840	$39
1.5	0.780	0.852	$48
2	0.791	0.864	$56
3	0.814	0.888	$73
5	0.839	0.890	$69
7.5	0.846	0.902	$97
10	0.864	0.910	$111
15	0.875	0.916	$149
20	0.886	0.923	$186
25	0.897	0.929	$224
30	0.901	0.931	$273
40	0.908	0.934	$371
50	0.915	0.938	$469
60	0.916	0.940	$553
75	0.917	0.944	$678
100	0.919	0.950	$887
125	0.924	0.952	$1,172
150	0.930	0.953	$1,457
200	0.940	0.956	$2,027
250	0.943	0.956	$2,159

General Energy

Motors and Drives

Checklist

Does the facility operate production motors for a full shift (or more)?

☐ Yes ☐ No
(If No, STOP)

1. Does the facility purchase high-efficiency motors when older motors fail?

☐ Yes ☐ No
(If No, See A)

2. Does the facility have many small motors, or a few large motors over 20 HP (Check nameplate for information)?

☐ Yes ☐ No
(If Yes, See A)

3. Do the drives on the motors have high-efficiency (cogged) V-belts?

☐ Yes ☐ No
(If No, See B)

Additional Questions

What is the horsepower and efficiency of the motors for which cost savings information is desired?

MEDS Links (http://meds.mmtc.org)

- Cog Belts
- High Efficiency Motors
- Magnetically Coupled Variable Speed Drives
- Synthetic Lubricants

General Energy

Power Factor

This tool provides an explanation of power factor, a cost/ savings analysis, and some implementation possibilities. Determining the exact configuration appropriate for the plant is beyond the scope of this assessment and best left to a qualified electrical contractor. A facility may find out its power factor by using services from the local utility office or hiring a contractor (such as an MEP Center) to get a better understanding of their future power factor concerns.

By installing capacitors in the facility, power factor charges can be eliminated.

A. Explanation of Power Factor

The ratio of real, usable power (kW) to apparent power (kVA) is known as the Power Factor (PF). To reduce reactive losses, the user should increase the PF to a value as close to unity (1.0) as is practical for the entire manufacturing plant. The utility supplying electricity to your facility assesses a power factor charge when the PF falls below a specified level because more apparent power must be supplied as the user's PF decreases.

For example, assume that a manufacturing plant has an average annual PF of 0.78. A PF of 0.78 means that for every 78 kW of usable power that the plant requires, the utility must supply 78 kW/PF or 100 kVA. If the plant's PF is changed from 0.78 to 0.95, then for every 78 kW demanded by the plant, the utility need only supply 78 kW/0.95 or 82 kVA.

The utility requests maintaining a PF as near to unity as possible at all times. If the PF falls below a set number, it will assess a PF charge. The facility should check with their local utility to see what the minimum power factor number is before charges occur.

Capacitors can be installed at any point in the electrical system and will improve the power factor between the point of application and the power source. Capacitors can be added at each piece of equipment, ahead of groups of small motors, or at main services. The advantages and disadvantages of each point of installation are highlighted below.

B. Implementation

Once the amount of correction is known, the next step is to determine where to put the correction and what type of correction to put there. There are three different methods to be considered when installing capacitor correction. A decision to choose one of the methods depends mainly on the specific situation within the plant.

C. Economics

Power factor correction can prevent penalties from the local utility company.

D. Sample Scope of Work and Deliverables

Future projects related to Power Factor Analysis are not likely.

E. References

- http://home.earthlink.net/~eddieg/papers/paper1.html
- Marks' Standard Handbook for Mechanical Engineers, McGraw Hill, 1987

Potential Implementation Methods	Costs	Advantages	Disadvantages
Method #1 Capacitor installed at individual Equipment/Load	\$25/kVAR and \$4000+ for installation labor	Reduces kWh losses in conductors from source to motor location Inexpensive, but may cost more per kVAR than larger units Does not incur over correction problems when system is lightly load Simple installation, but time consuming	Although the installation is not electrically complex and could be installed by in-house electrical person, it is quite an involved operation with up to 75% of the motors in the plant receiving correction Potential harmonics complications
Method #2 Fixed Band of Capacitors installed at groups of equipment or whole facility	\$25/kVAR and \$2000 for installation labor	Inexpensive Because the capacitors are located at only a few points within the system, the installation is rather simple.	Does not reduce kWh losses in conductor from source to motor location. Can incur over correction problems when system is lightly loaded. Potential harmonics complications
Method #3 Variable Bank of Capacitors installed at groups of equipment or whole facility	\$40/kVAR and \$2500 for installation labor	Does not incur over correction problems when system is lightly load.	Does not reduce kWh losses in conductor from source to motor location. Expensive Potential harmonics complications

Note: Access the MAP web site for a more complete description of the aforementioned method options and a discussion of the potential harmonics complications related to the correction of a power factor problem.

General Energy

Power Factor

Checklist

Is the facility incurring a power factor penalty on their electric bill?

☐ Yes ☐ <u>No</u>
(f No, STOP)

1 Does the facility have power factor correction already, or has the facility already installed capacitors?

☐ Yes ☐ <u>No</u>
(If No, See A)

2 Is a power factor penalty occurring every month?

☐ <u>Yes</u> ☐ No
(If Yes, See A)

Additional Questions

- What is the Current Power Factor (kW/kVA) from electric bills and the Annual Electric Usage, AEU (kW-Hours) to calculate the Power Factor Correction?
- What is the Current Power Factor?
- What is the Annual Electric Usage?

MEDS Links (http://meds.mmtc.org)

Capacitors